

Broadcast Data Receiver and Method of Use Thereof

This invention relates to a broadcast data receiver (BDR) and a method of use of said BDR.

The BDR referred to in the following description typically includes a display screen connected to or integrally formed with the BDR. The BDR allows for the generation of audio, visual and auxiliary data from digital data received from a broadcaster. In normal operation, a BDR receiving digital data will derive accurate frequency information from a stable reference embedded in the broadcast data stream.

BDRs typically contain a voltage controlled crystal oscillator (VCXO) generating a local frequency which is usually varied by up to ± 100 ppm about a nominal frequency, typically 27MHz. Off air MPEG transport stream/broadcast data streams have stable reference control signals embedded therein which are common to a 90KHz system clock reference (SCR). The microprocessor of a BDR produces a suitable pulse width modulated (PWM) waveform based on the SCR value to control the frequency of the VCXO. An accurate VCXO frequency allows accurate colour subcarrier frequency generation, thereby allowing the generation of the final video output.

Storage means such as low cost, high capacity hard disk drives are now being used for the recording and playback of audio and video data in BDRs. On occasions when the BDR is disconnected from the signal feed from the broadcaster, video data is read from the hard disk drive. Under these circumstances an accurate SCR is unavailable, as even though the stable reference signal can be recorded on the hard disk drive, upon playback it will have lost its accuracy. This is because it is being replayed under the control of the local VCXO frequency, which

is not a stable reference, rather than the SCR frequency it was originally broadcast at.

PAL decoders in televisions take composite video signals (i.e. video signals containing luminance, colour and synchronisation pulses which are generated by BDRs from the video output of BDRs and recover the constituent red, green and blue components for display on the screen of the television or monitor. The PAL decoder in an average television can lock to a colour subcarrier frequency generated by the VCXO deviating by up to $\pm 200\text{Hz}$. This equates to $\pm 45\text{ppm}$ about the subcarrier frequency of 4.43361975MHz . If the free run frequency of the 27MHz VCXO deviates beyond this point, as it can do when an inaccurate PWM is generated due to the absence of a stable SCR value, it is possible for the PAL decoder to lose colour lock. This can result in colour loss to the image displayed on the display screen, which is undesirable.

A similar problem is encountered when playing back BDR recordings on a video cassette recorder (VCR), for example if the user is trying to clear hard disk space in the BDR by transferring data onto a VCR. VCR's are less tolerant to errors in colour carrier frequency than television systems and can introduce further errors to the recorded SCR. As such, when the recording has been transferred from the BDR to the VCR and the VCR is then played back on the display screen of the television system, the error in the colour sub-carrier frequency results in deviations in PWM greater than the PAL decoder of the television can lock onto. This results in colour loss of the image displayed on the display screen.

The aim of the present invention is to provide a method for the production of a pseudo stable reference control for the reliable

generation of composite video signals replayed from storage means using a BDR.

According to a first aspect of the present invention there is provided a method for the production of a pseudo stable reference control for the reliable generation of composite video signals from a broadcast data receiver (BDR), said BDR receiving video, audio and/or auxiliary data from a broadcaster, said BDR having storage means in which to store data and characterised in that said method includes the steps of said BDR producing a pseudo stable reference by extracting/deriving one or more values from frequency information embedded in incoming broadcast data and using said pseudo stable reference to control the frequency of a VCXO in the BDR, thereby allowing accurate colour sub-carrier frequency generation for the generation of a video output via the BDR, or a VCR communicating with said BDR.

In one embodiment the one or more values are average values of stable frequency information/references embedded in incoming digital and/or analogue data.

Preferably the pseudo stable reference is stored in the storage means and updated over pre-determined time intervals.

Preferably the storage means is in the form of a hard disk drive.

Preferably the BDR includes micro-processing means which can extract data embedded in broadcast data streams and produce a suitable PWM signal. The PWM is then used to control the local frequency of the VCXO.

Preferably an algorithm is employed within the BDR software, to monitor and record the PWM signal(s).

Preferably the values used for the pseudo stable reference are average PWM readings recorded during the phase locked loop of software routine of the microprocessor.

The phase locked loop software compares the 90KHz stable frequency reference of SCR from the data stream to the local frequency value of the VCXO. The software operates to minimise the difference between the exact count of 90KHz stable clock cycles and the clock cycle count of the BDR local crystal oscillator, and preferably these should be the same. If there is any difference then the software either increases or decreases the VCXO frequency until the local 90KHz counts match those of the incoming data stream.

Preferably the one or more average PWM values include the mean or median average readings.

In one embodiment the pseudo stable reference is the average of the current PWM value, the most recent PWM value stored in the BDR/microprocessor and the oldest PWM value stored in the BDR/microprocessor. The values can be stored in memory in the BDR with the memory being of any suitable non-volatile form such as the Hard Disk Drive memory or EEPROM memory as both of these types will maintain the data in memory if the power supply is removed.

Preferably a timer is provided in the BDR to allow a pre-determined time period to pass before the microprocessor records a PWM value. This time period allows for temperature equilibrium of the BDR

In one embodiment the one or more values are derived by locking the frequency of the VCXO in the BDR to an off air

data stream and using the frequency information embedded in the off air data stream as the pseudo stable reference to control the frequency of the VCXO. The locking can be performed by using conventional phase locked loop algorithms and this, in turn, allows the generation of the pseudo stable reference when there is no live off-air signal.

Preferably if there is a choice of digital or analogue broadcast signals from which the one or more values can be derived therefrom, the BDR derives the one or more values from an analogue data signal.

Preferably locking of the frequency of the VCXO within the BDR to an off air data stream is undertaken during or at the same time as playback of data stored in the BDR and/or VCR.

Preferably the BDR records and stores one or more extracted stable frequency reference values from the off air data stream at pre-determined time intervals, so that if locking of the BDR to the off air data stream is lost during playback of stored data from the BDR and/or VCR, the BDR uses the last recorded stable frequency reference value to continue playback of the stored data. Once locking of the BDR to the off air data stream is resumed, the last recorded stable frequency reference value is discarded and the stable frequency value taken from the off air data stream is used.

If the BDR is provided with means to watch and record different television channels simultaneously and when the BDR is recording data from one or more channels, the BDR switches the front end of the record channel(s) off, extracts the stable reference value(s) from the data stream of the channel being watched and uses the stable reference value to lock the watch and record channels together. If one of the watch and the record

channels is an analogue channel, and the stable frequency value from this channel is used to lock the watch and record channels together.

Preferably the record channel(s) include(s) any or any combination of a channel from which data is being recorded onto a VCR or BDR, a channel being used to play back video data from the BDR, or a recording mode in which digital data is being copied from the BDR onto a VCR.

According to a second aspect of the present invention there is provided a broadcast data receiver, said BDR receiving video, audio and/or auxiliary data from a broadcaster, said BDR having storage means in which to store data and characterised in that the BDR is provided with means for producing a pseudo stable reference by deriving/extracting one or more values from frequency information embedded in incoming data, and said pseudo stable reference is used to control the frequency of a VCXO in the BDR, thereby allowing the generation of an accurate sub-colour frequency for the playback of stored data from the BDR and/or a VCR.

The pseudo stable reference is typically used when the BDR and/or VCR is deriving video data from said storage means.

In one embodiment the one or more values are average values of stable frequency information embedded in incoming data.

In an alternative embodiment the one or more values are provided by locking the reference from the VCXO within the BDR to an off air data stream, and one or more stable reference values embedded in said off air data stream are used to generate a pseudo stable reference control.

The present invention therefore allows hard disk drive video playback to be performed with conventional television receivers to produce a composite video image that can be displayed or archived onto videocassette/hard disk drive under typical domestic operating conditions. The pseudo stable reference is used as there is no accurate frequency information embedded in incoming digital data.

An advantage of the present invention is that it avoids the need for an expensive high stability free running oscillator to be used in the BDR. In addition, the effect of using a pseudo stable reference to drive/control the VCXO, which is updated at regular intervals, is to self compensate against the effects of crystal ageing (which results in frequency drift).

A further advantage of the present invention is that any seasonal changes in temperature in the operating environment of the BDR are automatically compensated for. The method is cheap and no additional hardware is required other than a standard BDR.

Embodiments of the present invention will now be described with reference to the following description:

In one embodiment of the present invention in normal operation, the microprocessor of the BDR records the SCR (stable clock reference) embedded in incoming data streams during the phase locked loop software routine and produces a suitable PWM to control the frequency of the VCXO. The PWM readings are recorded in the non-volatile memory of the BDR at regular intervals, and can then be used subsequently as a pseudo stable reference when retrieving transport stream data from the hard disk drive.

The PWM reading stored in the non-volatile memory is typically a representative value of the BDR in temperature equilibrium. A timer can be activated in the BDR to allow a sufficient 'warm up' time to pass before the PWM reading is recorded and stored. This warm up time may be necessary if, for example, the BDR has been left in a standby condition for an extended period of time.

The 'warm up' time can be determined by monitoring the time contained within the digital video broadcast (DVB) service information (SI), or from an embedded real time clock. It is not necessary to store both the time and the PWM reading in the non-volatile memory of the BDR.

The pseudo stable reference can be based on the means or median average of PWM values taken over a pre-determined period of time. It will be understood by persons skilled in that art that a number of different methods of calculating average readings be used to drive the VCXO at a suitable frequency.

For example, the PWM reading can be recorded after approximately 30 minutes of the BDR being activated from a standby condition. This reading will be referred to as the current reading [PWM current].

In the non-volatile memory of the BDR, two previous PWM readings are stored; [PWM recent] and [PWM oldest].

The average of the three PWM readings are taken to produce the pseudo stable reference:

$$\frac{[\text{PWM current}] + [\text{PWM recent}] + [\text{PWM oldest}]}{3}$$

The pseudo stable reference is then used as the VCXO drive value when playing back data from the hard disk of the BDR. An accurate VCXO value allows the PAL decoder to lock onto the colour subcarrier frequency and prevents colour loss of the image displayed on the display screen.

This calculated reference value can then become the new PWM[recent] and is stored in the memory. The old PWM[recent] becomes the PWM[oldest] and is stored in the memory and the old PWM[oldest] reading is deleted from the memory.

The above process can be repeated over pre-determined time intervals. If the BDR is in a standby condition for more than 24 hours, the BDR can be moved from the standby condition to an "on condition" and allowed to reach temperature equilibrium before the PWM reading is taken, typically using the timer.

Non-volatile memory employing EEPROM technology can be used and this typically allows approximately 10,000 reliable read/write cycles to be undertaken. This equates to 27 years of operation of the memory if the PWM value is updated once every 24 hours and shows that the working life of the BDR is not compromised by the introduction of the present invention.

It can be seen from the above description that the method of the present invention reduces the effect of any non-representative high or low PWM values that may have previously been sampled and allows the VCXO to be driven at a frequency similar to the SCR value of the originally broadcast data.

In an alternative embodiment of the present invention in normal operation, when the BDR is required to playback digital data stored on its hard disk drive, either directly onto a television screen or indirectly via copying the digital data onto a VCR

storage means, the BDR locks onto an off air data stream and derives a pseudo stable reference control value therefrom. This reference is based on the stable clock reference (SCR) embedded in the data stream. The extraction of SCR data is typically performed by the microprocessor in the BDR and the remaining data of the data stream is discounted. The microprocessor uses the derived SCR value to produce a suitable pulse width modulated (PWM) waveform to control the voltage controlled crystal oscillator (VCXO) of the BDR. The colour subcarrier frequency generated by the VCXO is then locked onto by the PAL decoder of the television to prevent colour loss of the image displayed on the television display screen.

In a similar manner, when digital data is being transferred from the BDR to a video cassette recorder (VCR), the BDR locks onto an off air data stream and derives a pseudo stable reference control based on the stable reference embedded in the off air data stream. The pseudo stable reference control value is then used to set the VCXO of the BDR to ensure that the digital data being copied onto the VCR has an accurate SCR value. This is particularly important as VCR's are less tolerant to errors in colour carrier frequency than television systems, and can introduce further errors to the VCR recorded SCR. Thus the pseudo stable reference prevents colour loss of images displayed on the television display screen from VCR data, which in turn has been recorded from BDR data.

The BDR records SCR values from off air data streams at pre-determined time intervals and stores these values in storage means of the BDR. In the event that during playback of stored digital data from the BDR, locking of the BDR to the off air data stream is lost, the BDR uses the last recorded SCR to continue playback of stored digital data without any loss of colour of the vide output. Once locking of the BDR onto an off

air data stream is restored, the BDR reverts to deriving pseudo stable reference values from the SCR embedded in the off air data stream.

In the event that the BDR is provided with multi-tuners (i.e., has the ability to allow a channel to be watched whilst recording a different channel) at least two SCR values will typically be present in the BDR. This may result in an error in setting the VCXO to the correct frequency for either, or both, of the channels being recorded and watched. In order to prevent this error, the present invention provides means for switching the timing control SCR values of the record channel off. A pseudo stable reference is then derived from the SCR embedded in the off air data stream of the channel being watched. This pseudo stable reference value is then used by the record channel to lock the watch and record channels together.

The recorded channel can include a channel from which data is being recorded onto a VCR or a BDR, a channel being used to play back video data from the BDR or a recording mode in which digital data is copied from the BDR onto the VCR.